PRELIMINARY SURVEY OF BIODIVERSITY IN NEW CHICAGO MARSH

FINAL REPORT
SAN FRANCISCO BAY NATIONAL WILDLIFE REFUGE

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ABSTRACT

During the late winter and early spring 1995, we conducted a preliminary survey of biodiversity in New Chicago March (NCM), at the south end of San Francisco Bay, Santa Clara County, California. The site, a diked salt marsh, is part of the San Francisco Bay National Wildlife Refuge Complex. Working from established transects, we measured the percent cover and height of vegetation, hand-trapped, netted, and seined invertebrates and fishes, black-lighted insects, conducted time-constrained searches for amphibians and reptiles, used point counts for birds, carried out sweep surveys and night spotlighting for larger mammals and live-trapped smaller mammals. There has been an apparent increase in the height of pickleweed over the past decade. We found numerous species of invertebrates that we classified into 16 separate orders. Several species of animals not previously reported at NCM were recorded such as the three-spined stickleback (*Gasterosteus aculeatus*), rainwater killifish (*Lucania parva*), California slender salamander (*Batrachoseps attenuatus*), southern alligator lizard (*Elgaria multicarinata*), western racer (*Coluber constrictor*), numerous raptorial birds including the peregrine falcon (*Falco peregrinus*) and the long-tailed weasel (*Mustela frenata*). Alien red foxes (*Vulpes fulva*) used the upland areas of the site for denning. The most significant result of this study was the discovery of a high population abundance of the salt marsh harvest mouse (*Reithrodontomys raviventris*), a federally-endangered species that is sometimes abundant in diked salt marshes. Further studies are needed to determine why high abundances sometimes occur in diked salt marshes.

INTRODUCTION

New Chicago Marsh (NCM) is home to at least one federally-endangered species, the salt marsh harvest mouse (*Reithrodontomys raviventris*), and potentially home to others. The salt marsh habitats of NCM are cut off from the tidal influence of San Francisco Bay leading to limited nutrient exchange (Hecht *et al.* 1990). Consequently, these habitats require careful monitoring and management. There is a dearth of biological information to aide in the conservation of this site. We conducted a series of investigations to identify and enumerate plant, invertebrate and vertebrate species living on the site that will provide baseline information for use in the development of future management strategies.

STUDY AREA

New Chicago Marsh is located near Alviso, Santa Clara County, California. It is part of the San Francisco Bay National Wildlife Refuge Complex and is managed by the U.S. Fish and Wildlife Service. It is approximately 142 ha in size, which is a small fragment of the once extensive tidal marshes of the San Francisco Bay (Fig. 1). The predominant soil within the tidal marshes of San Francisco Bay is a mineral Novato type. Within New Chicago marsh, the soil has been significantly altered by diking and drainage so that it has changed to a Reyes type. Reyes soils are more compacted, have lower soil moisture content, a higher pH, and higher salinity than Novato Soils (Eicher, 1988).

The primary vegetation of the marsh is pickleweed (*Salicornia pacifica),* interspersed with unvegetated flats, water channels, seasonal ponds, and higher vegetated areas. Until the mid-1980's, the area had been completely diked from tidal action for over 100 years. In 1978, San Jose/Santa Clara Sewage Treatment plant accidentally released 378 million liters of raw sewage into the South Bay. As a result, New Chicago Marsh became a mitigation site for salt marsh restoration efforts. Due to ground water overdraft between 1900-1963, the area subsided between 0.61 and 1.52m below NGVD. Consequently, full tidal action cannot be restored without inundating the site. At the present time, water enters NCM via a culvert from Triangle Marsh and is maintained at a level of about -61 cm NGVD with the use of a manually operated tide gate at the inlet, and pumps at the outlet (Hecht *et al.* 1990).

METHODS

This survey was conducted from mid-February through late April, 1995. The field crew of 11 individuals worked mainly on Fridays between 0900-1500 hours but also carried out a night survey and some extended trapping (see beyond). Collection of organisms was limited to invertebrates. The sampling was designed to minimize impact on the salt marsh environment.

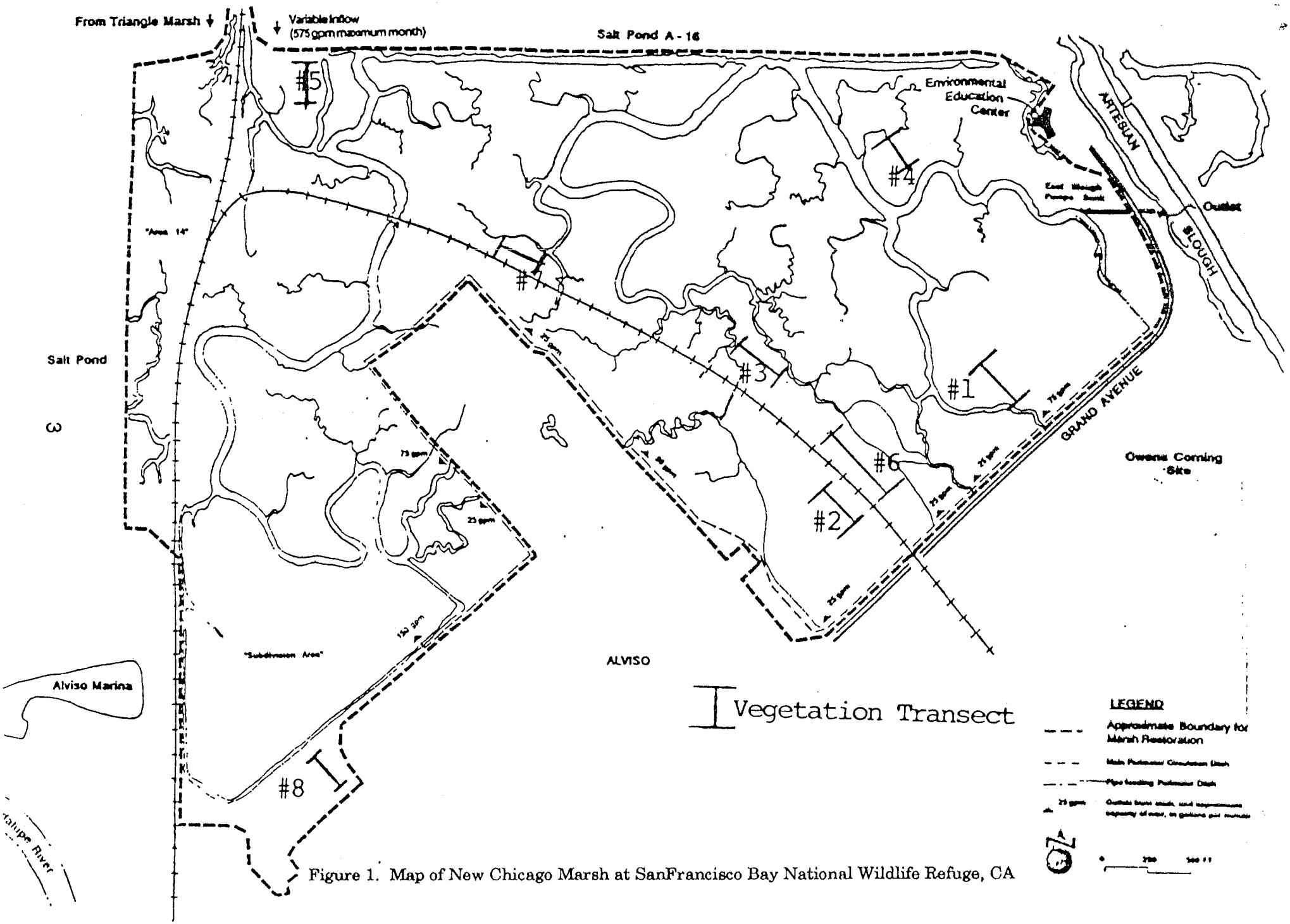

Figure 1. Map of New Chicago Marsh at SanFrancisco Bay National Wildlife Refuge, CA

VEGETATION

The sampling methods for vegetation followed the US Fish and Wildlife Service's protocol for NCM (Harding-Smith 1992, USFWS 1992) using eight permanent transects, 50m in length. We could not locate two of the original transects (2 and 8), therefore, we re-established them in their approximate former locations. All transects were re-marked at both ends with white PVC pipe driven into the ground so that they extended about 25 cm above ground level. Each pipe was marked with the transect number (Fig. 1).

Along each transect, we established 10 1/4 m^2 quadrats alternating on either side of the line at 5 m intervals. For each quadrat, we visually estimated the percent cover of plant species and bare ground to the nearest 5%. We also measured the heights of the tallest plants of each species within each quadrat. We further identified and measured the height of plants that resided every 10 m along each transect to coincide with the original USFWS measurements. Finally, where water was present, we recorded water salinity, temperature, and pH for each transect.

INVERTEBRATES

We used low-impact methods to determine species counts and relative abundance of invertebrates (Borror *et. al.* 1989). The sampling sites were the 50m vegetation transects established in 1992 and relocated for this study (see above). We sampled using either sweep netting or 1/4 m^2 surface quadrats, alternating these two techniques every 5m along the transect. When sweep netting, we covered an area of 3m^2 with a 25cm diameter insect net. When we employed surface quadrats on drier sites, we carefully searched through the vegetation and debris to identify and count the invertebrates present. If the quadrat intersected water, we dip netted to collect invertebrates.

The invertebrate surveys were conducted 2m from the transect line to avoid disturbing the vegetation directly on the line. Captured invertebrates were released unless field identification was not possible, in which case we collected them for later identification.

On the evening of 13 April 1995, we sampled invertebrates using a black (ultraviolet) light and a white sheet at night. We established one black lighting station on the northern side of the Education Center and collected organisms for later identification. We also seined several mudflat ponds near transect 1 (see Fig. 1) using a 0.5cm mesh net. We identified the invertebrates to the lowest determinable taxon, given the short time frame of the study.

VERTEBRATES

The fish survey was incorporated as part of dip netting and seining for invertebrates, as described previously. Amphibians and reptiles were sampled using time-constrained searches in suitable locations (uplands) throughout the study site (Bury and Raphael 1983). We identified and enumerated birds using point surveys

(Drost *et al.* 1988) at specific locations on the dikes near permanent transects 1, 3, 4, 5 and 8. Each survey lasted one hour and was conducted by two teams of 4-5 individuals each spaced 20m apart on the dike. The teams used 60x spotting scopes and binoculars to identify and count birds that resided in or flew over NCM. Most birds were identified within a 100m radius of the survey point, but some larger individuals were identified out to a distance of 300m from the point. At the end of the survey, data from both teams was compared and the highest count values were recorded.

For larger mammals, we carried out sweep surveys in upland areas surrounding the marsh, searching for the presence of tracks, scats and other sign (Gilbertson and O'Farrell 1986). The 11 team members maintained a straight line as we swept over the site, stopping to investigate and record each sighting as we located it. For fox burrows, we noted whether they were occupied by the presence of fresh tracks, scats and prey remains near the opening. We used night spotlighting from the roads and dikes surrounding the marsh to further search for larger mammal species. We conducted this survey one time on the evening of 13 April, 1995 with the aid of a 750,000 candle power spotlight.

To survey small mammals, we live-trapped using Sherman traps over two nights (13, 14, April 1995) at transects 1, 2, 5 and 6. At each site, we set 50 traps on a 50m by 100m grid. Traps were baited with bird seed and walnuts and set two hours before sundown. The captured rodents were measured, weighed and evaluated for behavior and belly coloration. They were released within two hours of sunrise.

We also recorded incidental sightings of any new species of animals when we encountered them. The recordings were accompanied by the times, dates, and locations of the sightings.

RESULTS

VEGETATION

Transects ranged from almost 100 percent cover of pickleweed to mixed vegetation consisting of brass button (*Cotula coronopifolia*), alkali heath (*Frankenia grandifolia*), grasses, and three weedy annuals. Pickleweed was the dominant plant in all transects, except transects 2 and 8. The mean heights of pickleweed ranged from 27.7 to 52.9cm with a grand mean of 39.9cm. The lowest mean height of pickleweed occurred on transect 1 which also had the highest percentage of bare ground. Brass buttons was found in significant abundance only on transect 2. Alkali heath, the second most abundant species, was present in moderate amounts in four transects. Only transects 3, 7, and 8 had standing water (Tables 1 - 11).

Table 1: Vegetation survey at transect # 1,
New Chicago Marsh, Santa Clara County, California, 17 March 1995.

	Pickleweed		Brass Buttons		Alkali Heath		litter	Bare groun
	% Cover	Ht. (cm)	% Cover	Ht. (cm)	% Cover	Ht. (cm)	% Cover	% Cover
Quadrat 1	30	33	10	23			5	55
Quadrat 2	70	37						30
Quadrat 3	60	17					10	30
Quadrat 4	25	25					10	65
Quadrat 5	55	34					45	
Quadrat 6	20	17						80
Quadrat 7	35	27						65
Quadrat 8	95	43				26		5
Quadrat 9	30	26		3				70
Quadrat 10	30	18			15	10		55
Mean	45	27.7		2.6		18	17.5	56.87
STDEV	24.15	8.96		14.14		11.31	18.48	18.50

Species occurrence and height (cm) every 10 m along transect.

Location (m)	Pickleweed
10	37
20	25
30	17
40	43
50	18
Mean	28
STDEV	11.58

Table 2: Vegetation survey at transect # 2,
New Chicago Marsh, Santa Clara County, California, 17 March 1995.

	Pickleweed		Brass Buttons		Alkali Heath		Grass		Bar
	% Cover	Ht. (cm)	% Cover	Ht. (cm)	% Cover	Ht. (cm)	% Cover	Ht. (cm)	grou
Quadrat 1	50	45	35	16	5	23			10
Quadrat 2	50	50	50	21					
Quadrat 3	15	50	65	30					20
Quadrat 4	20	30	75	23			5	27	
Quadrat 5	25	45	55	20			20	31	
Quadrat 6	25	34	75	19					
Quadrat 7	10	42	90	20					
Quadrat 8	30	35	60	23					10
Quadrat 9	30	51	60	21				30	10
Quadrat 10	45	40	45	18					10
Mean	30	42.2	61	21.1			12.5	29.3333	12
STDEV	14.14	7.36	16.12	3.78			10.61	2.08	4.4

Species occurrence and height (cm) every 10 m along transect.

Location (m)	Pickleweed	Brass buttons
10	23	
20		14
30	23	
40		40.00
50	30.00	
Mean	26.50	27.00
STDEV	4.95	18.38

Water pH
6.5

Table 3: Vegetation survey at transect # 3,
New Chicago Marsh, Santa Clara County, California, 17 March 1995.

	Pickleweed		litter	Bare ground	Water
	% Cover	Ht. (cm)	% Cover	% Cover	% Cover
Quadrat 1					100
Quadrat 2					100
Quadrat 3	100	51			
Quadrat 4	50	30		20	30
Quadrat 5			15		85
Quadrat 6	75	34		20	5
Quadrat 7	95	41		5	
Quadrat 8	95	53		5	
Quadrat 9	90	43		5	5
Quadrat 10	100	53			
Mean	86.43	43.57		11	54.00
STDEV	18.19	9.27		8.22	45.98

Species occurrence and height (cm) every 10 m along transect.

Location (m)	Pickleweed
10	30
20	34
30	53
40	53
50	42.5
Mean	42.5
STDEV	10.61

Water pH
6.5

Table 4: Vegetation survey at transect # 4,
New Chicago Marsh, Santa Clara County, California, 17 March 1995

	Pickleweed		Alkali Heath		Grass		Chickweed	
	% Cover	Ht. (cm)	% Cover	Ht. (cm)	% Cover	Ht. (cm)	% Cover	Ht. (cm)
Quadrat 1	95	47	5	20				31
Quadrat 2	15	31	5	21	50	28		
Quadrat 3	20	27	5	17	5	22		
Quadrat 4			50	18	10	19		
Quadrat 5	45	22	30	15	10	22		
Quadrat 6	55	27	0	0	10	21	20	14
Quadrat 7	50	28	30	24	20	18		
Quadrat 8	60	43	25	23	10	22		
Quadrat 9	75	33	10	17	15	24		
Quadrat 10	95	56	5	25				
Mean	56.67	34.89	16.5	20	16.25	2.75		11.25
STDEV	28.61	11.26	16.34	7.13	14.33	3.07		12.02

	Brass buttons		Unknown	
	% Cover	Ht. (cm)	% Cover	Ht. (cm)
Quadrat 1				
Quadrat 2				
Quadrat 3	30	11	15	8
Quadrat 4	5	7		
Quadrat 5				
Quadrat 6				
Quadrat 7		9		
Quadrat 8	5	13		
Quadrat 9				
Quadrat 10				
Mean	13.33	2.25		
STDEV	14.43	2.83		

Species occurrence and height (cm) every 10 m along transect.

Location (m)	Pickleweed	Alkali heath
10	31	
20		18
30	27	
40	43	
50	56	
Mean	39.25	
STDEV	13.07	

Table 5: Vegetation survey at transect # 5,
New Chicago Marsh, Santa Clara County, California, 17 March 1995.

	Pickleweed		Alkali Heath		litter
	% Cover	Ht. (cm)	% Cover	Ht. (cm)	
Quadrat 1	95	47	5	20	
Quadrat 2	100	47			
Quadrat 3	100	60			
Quadrat 4	100	61			
Quadrat 5	50	51	5	22	45
Quadrat 6	100	56			
Quadrat 7	100	66			
Quadrat 8	100	44		25	
Quadrat 9	100	47			
Quadrat 10	100	50			
Mean	94.5	52.9	5	6.67	
STDEV	15.71	7.40	0.00	2.52	

Species occurrence and height (cm) every 10 m along transect.

Location (m)	Pickleweed
10	56
20	22
30	24
40	31
50	39
Mean	34.4
STDEV	13.79

Table 6: Vegetation survey at transect # 6,
New Chicago Marsh, Santa Clara County, California, 17 March 1995.

	Pickleweed		Alkali Heath		Brass Buttons		Bare ground
	% Cover	Ht. (cm)	% Cover	Ht. (cm)	% Cover	Ht. (cm)	% Cover
Quadrat 1	100	49					
Quadrat 2	25	36	75	27			
Quadrat 3	5	43	95	32			
Quadrat 4	30	52	70	34			
Quadrat 5	75	57	25	27.5			
Quadrat 6	100	51					
Quadrat 7	20	61	80	26			
Quadrat 8	50	46	25	19			25
Quadrat 9		16	50	31			50
Quadrat 10	80	45			20	11	
Mean	53.89	45.6	60.00	28.07			37.5
STDEV	35.95	12.58	27.39	4.95			17.68

Species occurrence and height (cm) every 10 m along transect.

Location(m)	Alkali heath	Pickleweed
10	10	
20		42
30	27	
40	21	42
50	24	21
Mean	20.50	35
STDEV	7.41	12.12

Table 7: Vegetation survey at transect # 7,
New Chicago Marsh, Santa Clara County, California, 17 March 1995.

	Pickleweed		Alkali Heath		litter	Bare ground	Water
	% Cover	Ht. (cm)	% Cover	Ht. (cm)	% Cover	% Cover	% Cover
Quadrat 1	10	36	70	32	20		
Quadrat 2	45	41	5	19	50		
Quadrat 3		14	55	24	45		
Quadrat 4	45	30	30	17	25		
Quadrat 5	45	33	50	32		5	
Quadrat 6	90	49			10		
Quadrat 7	100	44					
Quadrat 8	80	58			10		10
Quadrat 9	75	43					25
Quadrat 10	50	44				10	30
Mean	54	39.2	42	24.8	26.67	7.5	21.6667
STDEV	28.28	1.19	25.15	7.05	17.22	3.54	10.41

Species occurrence and height (cm) every 10 m along transect.

Location (m)	Pickleweed
10	37
20	25
30	17
40	43
50	18
Mean	28
STDEV	11.58

Water salinity
1.50%

Table 8: Vegetation survey at transect # 8,
New Chicago Marsh, Santa Clara County, California, 17 March 1995.

	Pickleweed		Alkali Heath		Grass		Rumex		Water
	% Cover	Ht. (cm)	% Cover	Ht. (cm)	% Cover	Ht. (cm)	%Cover	Ht. (cm)	
Quadrat 1	25	38	5	18	30	37	5	9	100
Quadrat 2	35	43	5	25	50	52			
Quadrat 3	30	32	50	34	5	60			
Quadrat 4	60	51	25	14	40	57			
Quadrat 5			100	44	75	35			
Quadrat 6			5	20					
Quadrat 7				27	90	40			
Quadrat 8		37			75	42			
Quadrat 9	100	49							
Quadrat 10									
Mean	50	33.50	27.14	26	52.14	6.59			
STDEV	31.02	7.37	37.90	10.28	29.84	10.06			

Species occurrence and height (cm) every 10 m along transect.

Location (m)	Alkali heath	Grass
10	13	
20	16	
30		37
40		36
50	30	
Mean	19.66	36.50
STDEV	9.07	0.71

Water salinity
1%

Water pH
7.8

Table 9. Percent cover by transect of plant species occurring in New Chicago Marsh, Santa Clara County, California, 17 March 1995.

Feature	Transect #1	Transect #2	Transect #3	Transect #4	Transect #5	Transect #6	Transect #7	Transect #8
Pickleweed	45	30	60.5	51	94.5	48.5	54	25
Brass Buttons	1	61	-	4	-	2	-	-
Alkali Heath	1.5	0.5	-	16.5	1	42	21	19
Litter	7	0	1.5	6.5	4.5	-	16	4.5
Bare ground	45.5	3	5.5	5.5	-	7.5	2.5	4.5
Rumex sp.	-	-	-	-	-	-	-	0.5
Chickweed	-	-	-	2	-	-	-	-
Grass	-	2.5	-	13	-	-	-	36.5
Unident. Annual	-	-	-	1.5	-	-	-	-
Water	-	-	32.5	-	-	-	6.5	10

Table 10. Mean height of vegetation by transect in New Chicago Marsh, Santa Clara County, California, 17 March 1995.

Mean height (cm)	Transect #1	Transect #2	Transect #3	Transect #4	Transect #5	Transect #6	Transect #7	Transect #8
Pickleweed	28	42	44	35	53	46	39	42
Brass buttons	13	21	-	10	-	11	-	-
Alkali heath	18	23	-	20	22	28	25	26
Rumex sp.	-	-	-	-	-	-	-	9
Chickweed	-	-	-	23	-	-	-	-
Grass	-	30	-	22	-	-	-	-
Unident. Annual	-	-	-	8	-	-	-	-

Table 11. Water salinity and pH at transects 2, 3, 7, 8. New Chicago Marsh, Santa Clara County, California, 17 March 1995.

Transect #	Water salinity	pH
2	-	6.5
3	3	6.5
7	1.5	-
8	1	7.8

INVERTEBRATES

On 24 March 1995, we conducted two time-constrained searches; the first in the upland area south of the Education Center and the second near transect 8 (Fig. 1). The most abundant invertebrates in the upland area south of the Education Center were garden snails (*Otala lactea*) and earthworms (*Lumbricus terrestris*) (Table 12). The most abundant invertebrates at both sites were earwigs (Dermaptera), subterranean termites (Isoptera), and Argentine ants (Hymenoptera). Infrequent invertebrates included millipedes (Diplopoda) and cabbage moths (Lepidoptera) (Table 12, 13). On the evening of 13 April 1995 between 2030 to 2130 hours, we set up a black light in the vegetation just east of the Education Center and captured mosquitoes, one noctuidae, and numerous calyptrate and acalyptrate muscoid flies.

On 21 April 1995, we seined a mud flat pond near transect 1 and captured *Corophium* (Order: Amphipoda), water boatmen, and broad shouldered waterbugs. We also caught acalyptrate flies from the water's edge using a sweep net. On 28 April 1995, we surveyed transects 1-8 (Fig. 1) using sweep/dip net and surface 1/4 m^2 quadrat methods. Transects 7 and 3 had the highest diversity of invertebrates with seven different orders represented while transects 2 and 5 had the lowest diversity with only four invertebrate orders (Table 13). Spiders, midges, and mosquitoes were found on five or more of the transects.

Table 12. Time-constrained searches at area A (south of the Education Center) and area B (near transect 8), New Chicago Marsh, Santa Clara County, California, 24 March 1995. VA=Very Abundant (>40 individuals), A=Abundant (39-20), F=Frequent (19-10), IF=Infrequent (9-1), N=None.

Order	Common Name	Relative Abundance at A	Relative Abundance at B
Neogastropoda	Garden Snail	VA	N
Opisthopora	Earthworm	VA	A
Neogastropoda	Slug	F	F
Araneida	Spider	A	A
Chilopoda	Centipede	IF	N
Diplopoda	Millipede	IF	IF
Dermaptera	Earwig	VA	VA
Isoptera	Subterranean Termite	VA	VA
Odonata	Damselfly	N	IF
Lepidoptera	Cabbage Moth	IF	IF
Coleoptera	Darkling Beetle	IF	N
Coleoptera	Predaceous Diving Beetle	N	IF
Hymenoptera	Argentine Ant	VA	VA
Diptera	Acalyptrate Fly	N	VA

Table 13. Transect surveys from quadrat and sweep netting techniques on transects 1-8 in New Chicago Marsh, Santa Clara County, California, 28 April 1995.

Order	Family	Common Name	Transect #
Araneida	Multiple	Spiders	1,3,4,6,7,8
Acari	Unknown	Mites	6
Isopoda	Unknown	Sow bugs	8
Hemiptera	Corixidae	Water Boatman	7
Hemiptera	Veliidae	Broad Shouldered Water Bug	7
Homoptera	Cicadellidae	Leaf Hoppers	3
Homoptera	Aphididae	Aphids	2,3,8
Odonata	Unknown	Damselfly	4
Lepidoptera	Noctuidae	Cabbage moth	4,5,7
Coleoptera	Anthicidae	Ant-Like Flower Beetle	1,3
Coleoptera	Coccinellidae	Ladybird Beetle	2,4
Coleoptera	Carabidae	Ground Beetle	7,8
Hymenoptera	Formicidae	Argentine Ants	8
Diptera	Culicidae	Mosquitoes	2,4,5,6,7
Diptera	Chironomidae	Midges	1,2,3,5,6,7,8
Diptera	Calyptrate	Calyptrate Muscoid Flies	1,3,6
Diptera	Acalyptrate	Unknown	1,3,7,8
Diptera	Tephritidae	Fruit Flies	2,4,5

VERTEBRATES

The two species of fish identified were the three-spined stickleback (*Gasterosteus aculeatus*) and rainwater killifish (*Lucania parva*). The three-spined sticklebacks were dip-netted in great abundance during a preliminary survey in a mudflat pond near transect 3 on 17 February 1995. Sticklebacks were also captured in lesser numbers while seining a seasonal pond east of transect 1 on 21 April 1995. At that same time and location, we also captured large numbers of rainwater killifish.

The most abundant reptile was the western fence lizard (*Sceloporus occidentalis*); there were two distinct color morphs, a dark sooty and a lighter patterned one (Tables 14, 15). On several occasions, we also caught southern alligator lizards (*Elgaria multicarinata*). We identified three species of snakes, i.e., the gopher snake (*Pituophis melanoleucus*), western racer (*Coluber constrictor*), and two subspecies of the western terrestrial garter snake (*Thamnophis elegans terrestris* and *T. e. vagrans*). We also found two specimens of the California slender salamander (*Batrachoseps attenuatus.*) during a preliminary survey near transect 8.

The majority of birds recorded at transect 1 were Anseriformes, especially the northern shoveler (*Spatula clypeata*) and Canada goose (*Branta canadensis*) (Table 16). There was also an abundance of unidentified gulls (*Larus spp.*). Of special interest was a pair of peregrine falcons (*Falco peregrinus*) engaged in play behavior. The survey at transect 1 was the only survey in which we sighted a green-wing teal (*Anas crecca*) .

Transect 8 had a large concentration of Charadriiformes, including black-necked stilts (*Himantopus mexicanus*), dowitchers (*Limnodromus spp.*), and American avocets (*Recurvirostra americana*) (Table17). This site provided the only observations of the long-billed curlew (*Numenius americanus*) and the dark-eyed junco (*Junco hyemalis*).

Transect 3 also had high numbers of Charadriiformes, in particular, unknown gulls (*Larus spp.*), dowitchers (*Limnodrus spp.*), black-necked stilts (*Himantopus mexicanus*) and greater yellowlegs (*Tringa melanoleuca*) (Table 18). Charadriiformes in moderate abundance were killdeer (*Charadrius vociferous*), least sandpiper (*Erolia minutilla*), and lesser yellowlegs (*Tringa flavipes*). This survey recorded the first and only sighting of the pied-billed grebe (*Podilymbus podiceps*).

Transect 5 had the highest abundance of Charadriiformes especially unknown gulls (*Larus spp.*), California gulls (*Larus californicaus*) and American avocets (*Recurvirostra americana*) (Table 19). This location provided the first sighting of Forster's tern (*Sterna fosteri*) and the only sighting of the western (*Aechmorphus occidentalis*) and horned grebes (*Podiceps auritus*).

The survey at transect 4 showed the greatest species diversity of all the sites (Table 20). Of particular interest, was the first and only sighting of Bonaparte's gull (*Larus philadelphia*), eared grebe (*Podiceps nigricollus*), and the lesser and greater scaup (*Aythya affinis* and *A. marila*). Ciconiiformes were more represented in this survey, due to increased abundances of great egrets (*Casmerodius albus*) and black-crowned night herons (*Nycticorax nycticorax*).

Few small mammals were trapped at transects 2 and 5. Transects 1 and 6 had the highest trapping success, totaling 40 of the 45 harvest mice caught (Tables 21-22).

Table 14. Sweep survey of upland area south of the Education Center, New Chicago Marsh, Santa Clara County, California, on March 24, 1995. Surveyed: 1100-1150 hrs.

Burrows	Occupied	Unoccupied
Red Fox	1	12
Squirrel	1	27
Unknown	2	

Scat	Frequency
Red Fox	2
Rabbit	2
Unknown	1

Live Vertebrates	Frequency
Bachman's cottontail	3
Black-tailed jackrabbit	3
Unknown lagamorph	1
Southern alligator lizard	2
Western fence lizard	2
Western terrestrial garter snake	1
Unk lizard	1
American bittern	1
Anna's hummingbird	1
Brn swallow	4
Brn towhee	1
Mallard	1
Long-billed marsh wren	2
Ring-necked pheasant	1
Sng sparrow	6
Unknown hummingbird	1
Unknown sparrow	32
Unknown swallow	1
Western meadowlark	2
White-crowned sparrow	2

Prey Remains	Frequency
Unk bird	4
unk intestines	1
unk lagamorph	4

Table 15. Vertebrates found during time-constrained searches of the New Chicago Marsh, Santa Clara County, California on 24 March 1995.

South of the Education Center. 1107 to 1137 hrs.

Herptiles	Frequency
Southern Alligator Lizard	7
Western Fence Lizard	33
Western Terrestrial Garter Snake	3

Other	
Cottontail rabbit	1
Ring-tailed Pheasant remains	1

Near Transect 8. 1415 to 1437 hrs.

Herptiles	Frequency
Gopher Snake	2
Western Fence Lizard	1

Other	
Occupied Ground Squirrel burrows	2

Table 16. Survey of birds near transect 1, New Chicago Marsh, Santa Clara County, California, 3 March 1995. Weather: cold, windy, rainy. Surveyed: 0927 to 1027 hrs.

Species	Frequency
Northern Shoveler	200
Unknown Gull	84
Canada Goose	46
Mallard	24
Great Egret	9
Gadwall	8
American Coot	6
Northern Pintail	6
Barn Swallow	5
Northern Harrier	5
Marsh Wren (Call Only)	4
White-Tailed Kite	4
Red-Tailed Hawk	3
Peep	2
Peregrine Falcon	2
Song Sparrow	2
Unknown Dowitcher	2
Violet-Green Swallow	2
Double-Crested Cormorant	1
Green-Winged Teal	1
Ruddy Duck	1

Table 17. Survey of birds near transect 8, New Chicago Marsh, Santa Clara County, California, 17 March 1995. Weather: overcast, warm. Surveyed: 0915 to 1015 hrs.

Species	Frequency
Black-Necked Stilt	93
Unknown Dowitcher	39
American Avocet	38
Northern Shoveler	26
Unknown Gull	23
Red-winged Black Bird	20
American Coot	19
Mourning Dove	9
Cinnamon Teal	6
Mallard	6
Gadwall	5
Common Raven	5
Long-billed Curlew	4
Great Egret	4
Western Meadowlark	4
Snowy Egret	4
Killdeer	3
Northern Harrier	3
Northern Pintail	2
Barn Swallow	1
Dark-Eyed Junco	1
Greater Yellowlegs	1
Mockingbird	1
Red-Tailed Hawk	1

Table 18. Survey of birds near transect 3 New Chicago Marsh, Santa Clara County, California, 24 March 1995. Weather: sunny, windy. Surveyed: 0920 to 1020 hrs.

Species	Frequency
Unknown Gull	251
Unknown Dowitcher	179
American Avocet	57
Black-necked Stilt	43
Greater Yellowlegs	13
Northern Shoveler	12
Great Egret	11
Killdeer	11
Least Sandpiper	11
Lesser Yellowlegs	10
Violet-green Swallow	9
Canada Goose	9
Mallard	8
Red-Winged Blackbirds	8
Cinnamon Teal	6
Snowy Egret	6
American Coot	5
Common Crow	5
Common Raven	4
White-tailed Kite	4
Barn Swallow	3
Gadwall	3
Northern Pintail	3
Northern Harrier	2
Double-Crested Cormorant	1
Great Blue Heron	1
Marbled Godwit	1
Marsh Wren	1
Western Meadowlark	1
Pied-billed Grebe	1
Song Sparrow	1

Table 19. Survey of birds near transect 5, New Chicago Marsh, Santa Clara County, California, 7 April 1995. Weather: cold, cloudy, windy. Surveyed: 0930 to 1030 hrs.

Species	Frequency
Unknown Gull	93
American Avocet	40
California Gull	34
Forster's Tern	21
Black-necked Stilt	20
Great Egret	17
Barn Swallow	15
Mallard	9
Northern Shoveler	8
Common Crow	7
Canada Goose	7
Black-crowned Night Heron	5
Great Blue Heron	5
Northern Pintail	5
Snowy Egret	5
White-tailed Kite	5
Western Grebe	4
Unknown Duck	3
Common Raven	2
Northern Harrier	2
Song Sparrow	2
Killdeer	1
Horned Grebe	1
Violet-Green Swallow	1

Table 20. Survey of birds near transect 4, New Chicago Marsh, Santa Clara County, California, 21 April 1995. Weather: cool, sunny, slight breeze. Surveyed: 0920 to 1020 hrs.

Species	Frequency
American Avocet	61
Ruddy Duck	38
Gadwall	27
Great Egret	26
Lesser Scaup	17
Unknown Gull	14
Barn Swallow	11
Northern Shoveler	11
Peep	11
Black-crowned Night Heron	9
Canada Goose	9
Mallard	9
Mourning Dove	9
Common Crow	8
Northern Harrier	7
Red-winged Blackbird	7
Black-necked Stilt	5
Bonaparte's Gull	5
Song Sparrow	5
Snowy Egret	4
American Coot	3
Black Phoebe	3
Eared Grebe	3
Forster's Tern	3
Unknown Scaup	3
European Starling	2
Great Blue Heron	2
Greater Scaup	2
White-tailed Kite	2
Common Raven	1
Killdeer	1
Long-billed Marsh wren	1
Red-tailed Hawk	1
Ring-billed Gull	1

Table 21. Capture data for Salt marsh harvest mouse
New Chicago Marsh, Santa Clara County, California, 14 April 1995.

Body lgth (mm)	Tail lgth (mm)	Tail diam (mm)	Tail color	Tail tip	Wt (g)	Belly color code	Activity
Transect 1							
64	61	2.4	uni, no white	intermed	10.5	7	placid
72	70	2.2	uni, no white	intermed	13.5	1	placid
72	64	2.1	uni, no white	intermed	13	7	placid
67	62	2.2	uni, no white	blunt	12.5	6	placid
69	62	2.2	uni, no white	intermed	11.5	6	placid
70	67	2.3	uni, no white	intermed	11.5	4	intermed
65	56	2.2	uni, no white	intermed	9.5	7	placid
75	70	2.5	uni, no white	intermed	14	5	intermed
Transect 2							
Transect 5							
68	60	2.2	uni, no white	blunt	11	6	intermed
Transect 6							
61	57	2.4	uni, no white	blunt	9	7	placid
72	62	2.5	uni, no white	blunt	12.5	7	placid
70	63	2.4	uni, no white	blunt	13	7	placid
69	71	2.3	uni, no white	intermed	14.5	7	placid
74	59	2.5	uni, no white	blunt	14.5	6	intermed
74	63	2.3	uni, no white	blunt	13	7	placid
65	60	2.2	uni, no white	blunt	12.5	7	intermed
63	61	2.4	uni, no white	intermed	11	6	placid

Salt marsh harvest mouse capture data - day two.
New Chicago Marsh, Santa CLara County, California, 15 April 1995.

Transect 1	Transect 2	Transect 5	Transect 6
13 harvest mice	2 harvest mice	2 harvest mice	11 harvest mice
2 meadow mice	one found in brass buttons	1 meadow mouse	3 meadow mice
1 meadow mouse (expired)			

Table 22. Numbers of harvest mice and meadow mice caught, respectively, at New Chicago Marsh
Santa Clara County, California, 14 April 1995.

Transect1	8	1
Transect 2	0	0
Transect 5	1	0
Transect 6	8	2

Day 2 - Numbers of harvest mice and meadow mice caught, respectively, at New Chicago Marsh
Santa Clara County, California, 15 April 1995

Transect1	13	2
Transect 2	2	0
Transect 5	2	1
Transect 6	11	3
Total	45	9

Table 23. Night spotlighting on 13 April 1995 in the New Chicago Marsh, Santa Clara County, California. Surveyed: 2040 - 2200 hrs.

Species	Frequency
Bachman's cottontail	6
Black-tailed jackrabbit	21
Unidentified canid (probable red fox)	1-2
Unknown owl species	2-4
Red-tailed hawk	1

We observed the exotic red fox (*Vulpes fulva*) on one occasion for sure (10 February 1995 during a early visit to the site) and probably on a second occasion (13 April 1995 during night spotlighting-see Table 23). We also recorded the presence of both active and inactive den sites in the upland area south of the Education Center during the sweep surveys (Table 14). We observed packs of domestic dogs (*Canis domesticus*) roaming through the marsh on various occasions. On 14 April 1995, there was one sighting of a long-tailed weasel (*Mustela frenata*) just east of the Education Center.

DISCUSSION

VEGETATION

The base-line study conducted by Harvey and Stanley (1986) used different methodologies and transect locations than this survey to evaluate the vegetation and, therefore, comparisons between the two studies must be made cautiously. Pickleweed continued to be the dominant plant species within the study area. Pickleweed cover values in 1986 ranged from 64% to 74% (Harvey and Stanley 1986), whereas the cover value in this study was 51%. This may represent an actual decline in the cover of pickleweed over the past decade or merely a difference due to the placement of transects between this study and the previous one. Bare areas were reported to cover 20% in 1986 and 9% in this study, also a possible result of transect placement.

Restoration efforts in the past have been aimed at increasing pickleweed cover and vigor (Hecht *et al.* 1990). This was to be achieved partially by increasing water flows into the marsh to leach salts from the soil. While we did not conduct in depth salinity studies, it seems possible that increased flows have reduced salinity levels leading to increased pickleweed vigor. The mean height of pickleweed for this study was 39.9cm, a 20 % increase in height over that reported by Harvey and Stanley (1986). Pickleweed height at NCM may be increasing but is still less than the height at undisturbed marshes (39.9cm versus 50cm) (Hecht *et al.* 1990).

INVERTEBRATES

We suspect that the record rainfall in January and March of this year, and the prolonged winter conditions that continued into May, adversely affected our ability to detect some of the invertebrates in the marsh. Diversity also could have appeared to have been low at some sites due to insufficient sampling time. The lack of prior invertebrate studies at NCM, precluded any comparisons of diversity with previous years.

The time-constrained searches allowed us to measure relative abundance of invertebrates at two sites. The upland site had a high abundance of garden snails which was probably correlated with the high abundance of Argentine ants. Snails are an important food source for ant colonies. Although no snails were recorded at the site near transect 8, the presence of earthworms, termites and other invertebrates provided food for the Argentine ants. At both sites, the accumulated

plant and animal matter supplied sufficient food for colonies of subterranean termites and earwigs.

Because the black light required proximity to an electrical outlet, we sampled above the marsh near the Education Center. Wind and cool temperatures are characteristics of marsh habitats that limit insect abundance there (Dr. Ronald Stecker, San Jose State University, pers. comm.) and consequently, we did not attract many insects to the black light.

Brackish water conditions of the marsh further inhibit invertebrate diversity. Species that can tolerate these conditions thrive because of lack of competition. *Corophium*, water boatmen, and broad shouldered water bugs were abundant and they undoubtedly served as food sources for fish and birds.

Invertebrate diversity was highest on transects 7 and 3 (short pickleweed habitat). In dense pickleweed habitat, i.e. transect 5, invertebrate diversity was low. It is possible that the thick cover reduced our ability to detect invertebrates. Interestingly, invertebrate diversity was low at transect 2, the most vegetationally-diverse habitat with Brass buttons, pickleweed, and non-native grasses. The higher plant diversity was largely the result of the presence of non-native species.

VERTEBRATES

Three-spined sticklebacks were found in greatest abundance in a channel which was filled with predominantly freshwater from Mallard and Artesian sloughs after a period of unseasonably heavy rain. Both the stickleback and killifish have a wide range of tolerances for oxygen, salinity, and temperature and are able to survive long after other species have died (Moyle 1976). The rainwater killifish may have been introduced to San Francisco Bay as eggs attached to the shells of oysters which were brought from the east coast for culture (Moyle 1976, Lonzarich 1989). There is no evidence that either the killifish or the stickleback was introduced directly into NCM, rather they have gradually become established and spread throughout the area.

Garter snakes, gopher snakes and western fence lizards have been identified previously at this site. However, this study represents the first records at NCM of the western racer, southern alligator lizard, and slender salamander (Appendix 1). Slender salamanders were found under a piece of wood near the abandoned enclosure in the upland area south of the Education Center on 24 February 1995. The other herptiles were also found at this site, with the exception of a garter snake which was captured at the edge of the marsh south of the Education Center and the two gopher snakes which were found near transect 8 under a piece of discarded carpet. The latter site is largely an upland with tall grasses and perennial vegetation.

The previous avian survey at NCM was conducted in 1983 by Valerie Layne (reported in Harvey and Stanley 1986) prior to active management of the marsh. We found a greater abundance and diversity of raptors than Harvey and Stanley (1986) who reported only the turkey vulture (*Cathartes aura*) and the northern harrier (*Circus cyaneus*). Our survey included seven species of raptors (Appendix 2), sightings of which were frequent throughout the study. Predatory bird populations are correlated to the abundances of prey species.

At NCM, prey mainly consisted of rodents such as salt marsh harvest mice, meadow mice (*Microtus californicus*), and house mice (*Mus musculus*) (Geissel et al. 1988), as well as lagomorphs and various bird species (Appendixes 2, 3).

Bird species that were present in 1983, but absent during this study included the cattle egret (*Bubulcus ibis*), whimbrel (*Numenius phaeopus*), burrowing owl (*Athene cunicularia*), barn owl (*Tyto elba*), cliff swallow (*Hirundo pyrrhonota*), water pippit (*Anthus spinoletta*), and Caspian tern (*Hydroprogne caspia*). It is possible that some of these birds were not sighted because we conducted this study earlier than Harvey and Stanley (1986). Winter conditions prevailed well into the spring of 1995 and this may have delayed the arrival and breeding activities for many birds.

Results of small mammal trapping showed higher numbers of salt marsh harvest mice than had previously been reported for diked marshes in general, and for NCM in particular. The highest capture efficiency thus far for the salt marsh harvest mouse was 11.8% (59 individuals/500 trap nights) while a more typical capture efficiency was 0.5% (Dr. Howard Shellhammer San Jose State University Pers. Comm.). The capture efficiency for this study was 45 individuals/500 trap nights (9%), the second highest known.

Shellhammer *et al.* (1985) and Geissel et al. (1988) characterized the harvest mouse as a fugitive species. During the prime of their reproductive cycle, meadow mice tend to dominate the best pickleweed habitat, forcing harvest mice and house mice into sub optimal habitats. When the reproductive cycle of the meadow mouse ceases, typically in late May, harvest mouse populations increase and the animals move into taller pickleweed (Shellhammer *et al.* 1982). The cessation of the reproductive cycle in meadow mice is related to the increase in salinity of the salt marsh. As the temperature warms later in the season and water is evaporated from the marsh, saline concentrations increase. Salt marsh harvest mice are competitively superior to meadow mice in the most saline environments, which includes most of the yearly cycle in diked marshes (Geissel *et al. 1988*).

Previous studies (Geissel *et al.* 1988, Harvey and Stanley 1986) indicate that April is usually a peak time for reproduction of meadow mice and a pre-reproductive period for harvest mice. In this study, we caught only nine meadow mice and no house mice. It is possible that the unusual weather conditions played a role in this. Drought conditions have persisted for most of the past seven years and have been replaced this year with unusually high precipitation.

On our initial visit in late February 1995, NCM was flooded. Through the course of the study the water receded. The flooded conditions may have pushed rodent populations to the higher edges of the salt marsh, e.g., near transect 1. Harvest mice climb the pickleweed to escape rising water, whereas meadow mice do not (Shellhammer *et al.* 1982). It is possible that meadow mice were not able to breed successfully this year which allowed harvest mice to begin their reproductive cycle earlier.

Previous trapping studies at NCM captured most harvest mice at transect 5, which has been considered the best habitat because of its higher, more dense pickleweed. During this study only three harvest mice were captured on that transect. Transect 5 is located at the lower end of the marsh and it is possible that

heavy rains forced harvest mice out of the area into other areas of the marsh. In previous studies, a few harvest mice were caught at transect 1. In this study 21 of the 45 harvest mice were caught at transect 1.

Transects 2 and 6 had not been trapped previously. In this study, we captured three and 19 harvest mice, respectively at these locations. Transect 2 had not been previously trapped apparently because researchers thought that harvest mice would not readily cross the raised dike and railroad tracks. It is possible that a population of harvest mice has existed undetected at transect 6 for a long time.

These results demonstrate that NCM is a dynamic habitat that is in need of further study and conservation. In particular, it may be a vital haven for the endangered salt marsh harvest mouse, with populations that are larger and more wide-spread throughout the marsh than previously thought. We recommend ongoing trapping studies to clarify whether this year's high population is an anomaly or is more typical of the site.

NCM also harbors a population of red foxes. Since these alien predators have been clearly implicated in causing a further decline in the population of the endangered clapper rail (Foerster and Takekawa 1991), they should be monitored and managed closely at NCM. This species has a reasonably large home range (Lewis *et al.* 1992), and consequently, if NCM is not periodically trapped, it may become a reservoir that replenishes the surrounding marshes with foxes. This would make the control of fox populations more difficult.

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Appendix 1. Common and scientific names of reptiles and amphibians observed at New Chicago Marsh, Santa Clara County, California, February to April 1995.

CLASS REPTILIA

Order SQUAMATA

Suborder Lacertilia

Western Fence Lizard	*Sceloporus occidentalis*
Southern Alligator Lizard	*Elgaria multicarinata*

Suborder Serpentes

Gopher Snake	*Pituophis melanoleucus*
Western Racer	*Coluber constrictor*
Western Terrestrial Garter Snake	*Thamnophis elegans*
	T.e. terrestris
	T.e. vagrans

CLASS AMPHIBIA

Order CAUDATA

Slender Salamander	*Batrachoseps spp.*

Appendix 2. Common and scientific names of birds observed at New Chicago Marsh, Santa Clara County, California, February to April 1995.

CLASS ARCHEOSAURIA

Order PODICIPEDIFORMES

Eared Grebe	*Podiceps nigricollus*
Horned Grebe	*Podiceps auritus*
Pied-billed Grebe	*Podilymbus podiceps*
Western Grebe	*Aechmorphus occidentalis*

Order ANSERIFORMES

Mallard	*Anas platyrhynchus*
Northern Pintail	*A. acuta*
Gadwall	*A. strepera*
American Wigeon	*Mareca americana*
Northern Shoveler	*Spatula clypeata*
Cinnamon teal	*Anas cyanoptera*
Lesser Scaup	*Aythya affinis*
Ruddy duck	*Oxyura jamaicensis*
Canada Goose	*Branta canadensis*

Order CHARADRIIFORMES

American Avocet	*Recurvirostra americana*
Black-necked Stilt	*Himantopus mexicanus*
Killdeer	*Charadrius vociferous*
Unknown Dowitcher	*Limnodromus spp.*
Marbled Godwit	*Limosa fedoa*
Greater Yellowlegs	*Tringa melanoleuca*
Lesser Yellowlegs	*T. flavipes*
Least Sandpiper	*Erolia minutilla*
Bonaparte's Gull	*Larus philadelphia*

California Gull	*Larus californicus*
Ring-billed Gull	*Larus delawarensis*
Forster's Tern	*Sterna forsteri*

Order PELECANIFORMES

Double-crested Cormorant	*Phalacrocorax auritus*

Order CICONIIFORMES

Great Egret	*Casmerodius albus*
Snowy Egret	*Leucophoyx thula*
Great Blue Heron	*Ardea herodias*
Black-crowned Night Heron	*Nycticorax nycticorax*
American Bittern	*Botaurus lentiginosus*

Order STRIGIFORMES

Short-eared Owl	*Asio Flammeus*

Order FALCONIFORMES

Turkey Vulture	*Cathartes aura*
Northern Harrier	*Circus cyaneus*
Cooper's Hawk	*Accipiter cooperii*
Red-tailed Hawk	*Buteo jamaicensis*
White-tailed Kite	*Elanus leucurus*
Peregrine Falcon	*Falco peregrinus*
American Kestrel	*Flaco sparverius*

Order GRUIIFORMES

American Coot	*Fulica americana*

Order GALLIFORMES

Ring-necked Pheasant	*Phasianus colchicus*

Order PASSERIFORMES

Black Phoebe	*Sayornis nigricans*
Barn Swallow	*Hirundo rustica*
Violet-green Swallow	*Tachycineta thalassina*
Red-winged Blackbird	*Agelaius phoeniceus*
Brown-headed Cowbird	*Molothrus ater*
Western Meadowlark	*Sturnella neglecta*
Marsh Wren	*Telamatodytes palustris*
American Goldfinch	*Carduelis tristis*
House Finch	*Carpodacus mexicanus*
Brown Towhee	*Pipilo fuscus*
White-crowned Sparrow	*Zonotrichia leucophrys*
Golden-crowned Sparrow	*Zonotrichia atricapolla*
Song Sparrow	*Melospize melodia*
Common Crow	*Corvus brachyrhyncho*
Common Raven	*C. corax*
European Starling	*Sturnus vulgaris*
Mourning Dove	*Zenaida macroura*
Anna's Hummingbird	*Calypte anna*
Loggerhead Shrike	*Lanius ludovicianus*

Appendix 3. Common and scientific names of mammals observed at New Chicago Marsh, Santa Clara County, California, February to April 1995.

CLASS MAMMALIA

Order RODENTIA

California Ground squirrel	*Spermophilus beecheyi*
Meadow mouse	*Microtus californicus*
Salt marsh harvest mouse	*Reithrodontomys raviventris*

Order LAGOMORPHA

Bachman's Cottontail	*Sylvilagus bachmani*
Black-tailed Jack Rabbit	*Lepus californicus*

Order CARNIVORA

Dog	*Canis domesticus*
Long-tailed Weasel	*Mustela frenata*
Red Fox	*Vulpes fulva*